UCRL-MA-149450

Operations Manual for the Portable NDA II Equipment (Version 2.2)

B.B. Bandong, J.L. Wong, J.D. Valentine, D.J. Decman

June 27, 2002

U.S. Department of Energy

Lawrence
Livermore
National
Laboratory

DISCLAIMER

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

Operations Manual

for the

Portable NDA II Equipment

(Version 2.2)

prepared by:

Bryan B. Bandong, James L. Wong, John D. Valentine and Daniel J. Decman
Lawrence Livermore National Laboratory
P.O. Box 808, Livermore, CA 94551

June 2002

Table of Contents

List of Figures

List of Figures continued . . .

1. Purpose

This document describes the operation and use of the Portable Nondestructive Assay (NDA) II equipment for use in the determination of ^{235}U enrichment of uranium of various chemical forms and contained in different vessels. The Portable NDA II is the next generation NDA equipment assembled by Lawrence Livermore National Laboratory (LLNL) for the Department of Energy's Highly Enriched Uranium - Transparency Implementation Program (HEU-TIP). Presented in this document is an overview of the enrichment measurement methodology, instructions for the assembly and disassembly of the equipment, description of and user's guide for the UMeter enrichment meter software and a section on system troubleshooting. Also included herewith are facility-specific information and parameters for each of the HEU-processing sites subject to the HEU Transparency Implementation Program.

2. Introduction

2.1. Enrichment Meter Principle

The portable system for measuring the ^{235}U enrichment of different chemical forms of uranium packaged in various containers is based on the enrichment meter principle. In this method, the enrichment of the sample is directly proportional to the net count rate of the 186-keV gamma ray emitted by ^{235}U. To determine the enrichment, the gross area of the 186-keV gamma-ray peak is corrected for spectral background contribution extracted on the high-energy side of the peak, where the spectrum is fairly stable and a wider region can be integrated. The method is valid for measuring the enrichment of bulk uranium samples of (a) homogeneous and uniform geometry, (b) large enough size to fill the field of view of the gamma-ray detector, and (c) infinite thickness of uranium with respect to the 186-keV ^{235}U gamma ray. The infinite thickness is defined as that amount of material that can attenuate the intensity of the 186-keV gamma ray by a factor of one hundred. For example, for uranium metal, this thickness is about 3 millimeters and for UF_6, it is 1.4 centimeters. The field of view of the detector is restricted by a collimator

assembly so that reasonably sized samples can fulfill the requirements of the enrichment meter principle. The "infinite thickness" condition is always met for the samples measured in the HEU Transparency Project.

2.2. System Overview

The Portable NDA II unit employs the AMPTEK GAMMA-X system, which bundles together a low power 30 x 30 mm Scionix-Holland™ NaI(Tl) scintillation probe and the pocket-sized AMPTEK MCA8000A multichannel analyzer. The scintillation probe features a complete design of scintillator and PMT base comprising the photomultiplier tube, high voltage power supply, hybrid preamplifier and spectroscopic shaping amplifier. Power and signal connections to the probe are provided through a single, shielded LEMO cable from the MCA. A high voltage monitor and control is provided at the back of the NaI(Tl) probe via a twenty-turn potentiometer. The probe housing is made of anodized aluminum with a thickness of 0.5 mm around the scintillation crystal.

The low power consumption makes the scintillation probe ideally suited for use with the battery operated MCA8000A. Two 1.5V size AA batteries provide at least 8 hours of continuous data acquisition operation. The MCA8000A can also be powered with a 9 to 12 VDC from an AC adapter (110V/60Hz).

A notebook laptop computer running Microsoft Windows® 95/98/NT/2000 or XP provides control of and spectrum display for the MCA8000A. A standard 9-pin RS-232 null modem cable is used for the communication link between the laptop computer and the pocket MCA. Lengths of up to 250 feet of the null modem cable may be used without loss of data or system performance degradation. The baud rate for the unit is selectable and can operate as high as 115 kilobytes per second.

A photograph of the Portable NDA II equipment is shown in Figure 1. The physical dimensions of the detector unit are 4 x 4 x 12 inches and it weighs about 5 kg (11 lbs). The shielding and collimator (0.5-inch diameter aperture) assembly restricts the field of view of the detector. The Pocket MCA8000A is mounted via an aluminum box attached to the shielding/collimator assembly. The scintillation probe is held in place in the shielding/collimator assembly by a 3-inch long stainless steel collar with a ¼-inch wall thickness. Such mounting arrangement provides for

additional background radiation shielding from the back of the detector without significantly adding to the overall weight of the detection unit.

Figure 1. Portable NDA II system

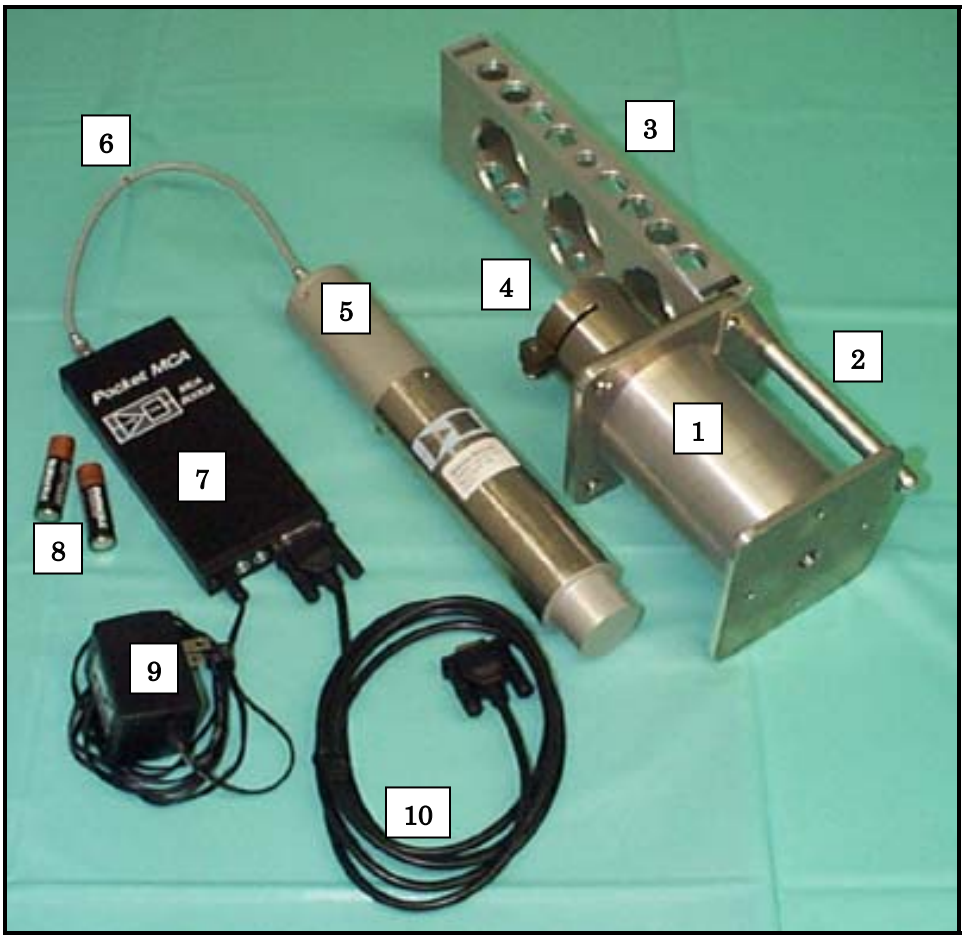
The scintillation probe high voltage power supply is set manually between 550 - 650 volts via a 20-turn potentiometer located at the back of the PMT base to position the 186-keV ^{235}U gamma-ray peak at about channel number 105 using a 512-channel ADC gain. The measured FWHM resolution for the 662-keV ^{137}Cs gamma-ray peak is typically 5.9%. Using measurements of a ^{226}Ra NIST standard, the observed spectral resolution at 186 keV is 10%.

The UMeter enrichment software developed for the Portable NDA II equipment operates on any of Windows® 95/98/NT/2000/XP platform. The UMeter enrichment code is written in Microsoft® Visual Basic 6.0. It links executable codes (".dll" files) and libraries (".lib" files) supplied with the software provided by AMPTEK Inc. for the control of the MCA8000A functions. The Visual Basic program provides for graphic menus and pop-up windows. The spectrum is displayed in real time as it is acquired. Accumulating the spectrum in real time is a good indicator that the equipment is operating properly and provides a quick feedback that HEU is really present. Live updates of the live time; the centroid and FWHM (after 1000 peak counts have been accumulated), net area and gross area of the 186-keV gamma-ray peak; the area of the reference background region and the MCA battery status are displayed.

3. System Components

3.1. Detector Unit

The components of the detector unit and the shielding/collimator assembly are displayed in Figure 2. When not in use, the unit can be stored in an aluminum carrying case (not shown).



1 - shielding/collimator assembly (lead + aluminum)
2 - carrying handle
3 - MCA8000A box (aluminum)
4 - NaI(Tl) probe collar mount
5 - NaI(Tl) scintillation probe 30 x 30 mm crystal
6 - LEMO cable (4-connector, Model FFA 0 S 304 CLAC42)
7 - Amptek Pocket MCA8000A
8 - 1.5-volt AA batteries
9 - 9 VDC/200 mA AC Adapter (not used in field measurements)
10 - DB-9F/DB-9F RS-232 null modem cable (female terminations)

Figure 2. Components of the Portable NDA II detector unit.

3.2. Laptop Computer

The equipment runs on any of commercially available PC notebook computers for the control and spectrum display of the MCA8000A. As an example, the cable connections applicable to the Portable NDA II equipment used with the IBM ThinkPad Model 390X PC laptop are shown in Figure 3. Figure 4 shows the power switch of the laptop.

Figure 3. Rear view and power cables for the IBM ThinkPad 390X PC laptop.

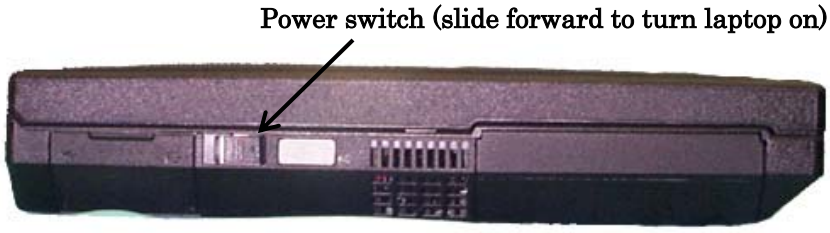


Figure 4. Left side view and power switch of the IBM ThinkPad 390X PC laptop.

4. Equipment Assembly & Cable Connections

The assembly of the equipment is straightforward and in general the order of the steps is not critical. There are only a few cable connections to be made between the MCA8000A, the NaI(Tl) scintillation probe and the PC laptop. A brief

discussion of the assembly of the shielding/collimator assembly is presented, although normally this part comes assembled when shipped for field measurements. It is also important to note that, in the Russian facilities, while the Russian technicians perform the operation of the equipment, the U.S. monitors are still responsible to ensure that these operations are performed correctly. The assembled detector unit is shown in Figure 5.

Figure 5. Portable NDA II detector unit (shown assembled). The NaI(Tl) scintillation probe is mounted onto the shielding/collimator assembly, and the MCA8000A is mounted on the aluminum box above the NaI(Tl) scintillation probe. The MCA8000A is connected to the probe with a LEMO cable. The RS-232 null modem cable and the 9V AC adapter are shown connected to the MCA8000A.

4.1. Shielding/Collimator

The order of assembly for the lead (Pb) collimators, the aluminum (Al) spacers, the Pb shield and the Al sleeve is shown in Figure 6. The Al spacers and Pb collimators are stacked in the order shown in the figure. This stack is then inserted into the Pb shield, and the Pb shield/collimator part in turn is inserted into the Al sleeve. The two Pb collimators have dimensions of ¼-inch thickness, ½-inch inner diameter (I.D.) and a 2-inch outer diameter (O.D.). The Pb shield measures 4.25 inches long with an O.D. of 2½ inches and a wall thickness of ¼-inch. Both Al spacers have an O.D. of 2 inches; one of the spacers measures 1½ inches long and the other is 2¼ inches long. Finally the Al sleeve has dimensions of 2½-inch I.D. x

3-inch O.D. x 4.25 inches long with four 4-40 tapped holes on both ends distributed at 90 degrees to each other. The shielding/collimator assembly is held in place by two 4-inch x 4-inch x ¼-inch thick Al faceplates (see Figure 5) using 4-40 cap screws. The front faceplate has a ½-inch collimator hole while the back faceplate has a1¾-inch center hole where the scintillation probe is inserted for mounting.

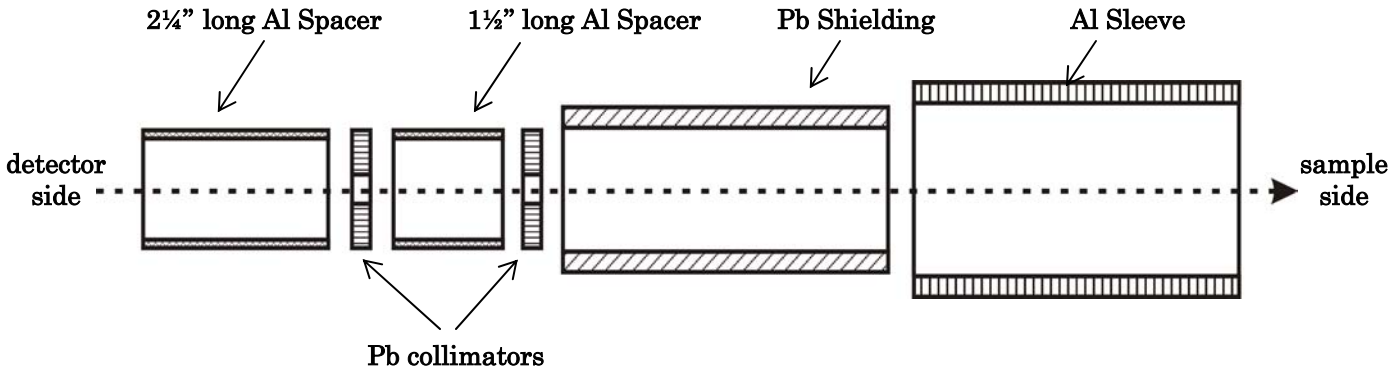


Figure 6. Shielding/Collimator components and assembly.

4.2. MCA Box

The MCA box is comprised of the AMPTEK MCA8000A unit and the Al mounting box (Figure 7). The box is configured to protect the cable connectors.

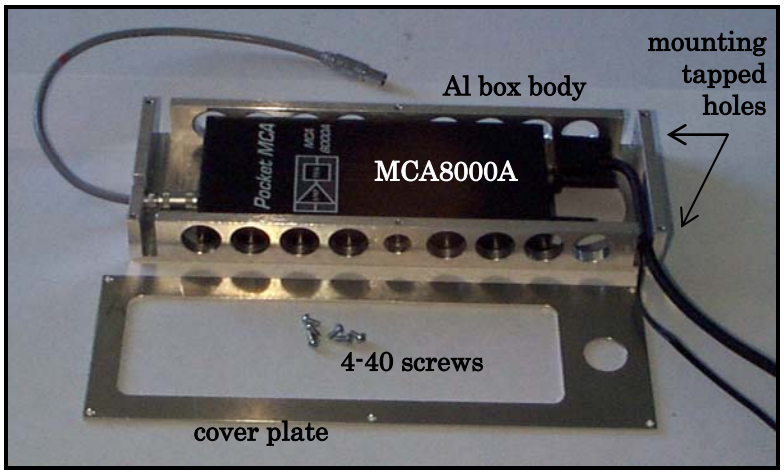


Figure 7. MCA Box unit. The MCA8000A unit is shown installed in the Al box.

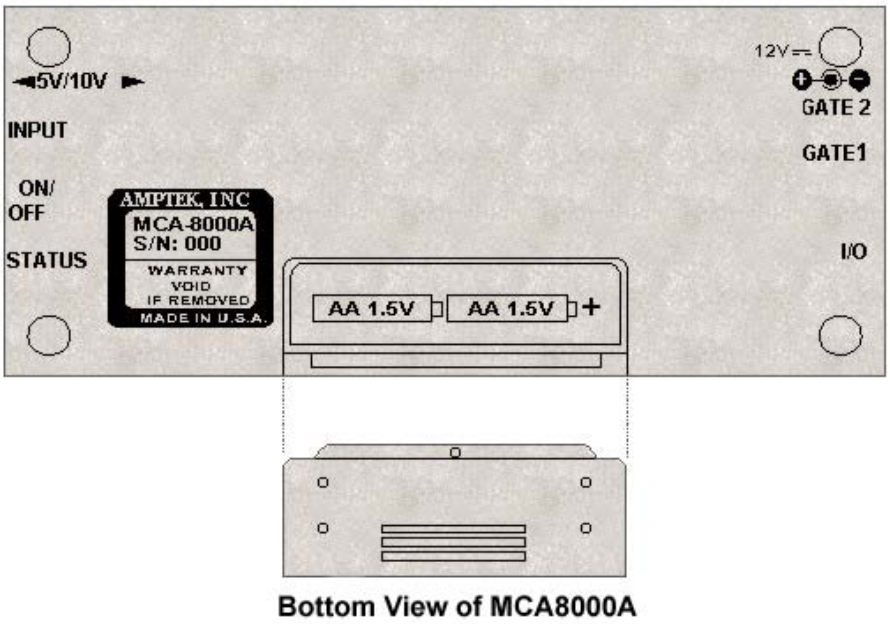
With cables already connected (see Section 4.5 below), the MCA8000A is placed into the Al box body from the top. Cutout slots are provided that serve as channels for the LEMO, RS-232 and AC adapter cables, with the LEMO cable positioned at the back end of the box. The cover plate is held in place by six 4-40 round head screws. The MCA box is then mounted onto the shielding/collimator assembly by two 8-32 screws using the mounting tapped holes on the MCA box.

Schematic drawings of the hardware features of the MCA8000A are presented in Figure 8. Photographs of the input and control sides are displayed in Figure 9. For the HEU enrichment measurements, the TTL logic Gates 1 and 2 are not used. The MCA is calibrated with the dynamic range switch for analog input pulses set at the +5 volt ("+5V") position. The baud rate for communication across the RS-232 interface is set to 115.2 kilobytes per second. The switch for setting the baud rate is located on the bottom of the MCA8000A and is beneath the Serial No. sticker. Figure 10 depicts the switch positions that correspond to four baud rates. The MCA should be powered off when setting the switch. A software setting must also be adjusted in conjunction with the switch setting to obtain the desired rate.

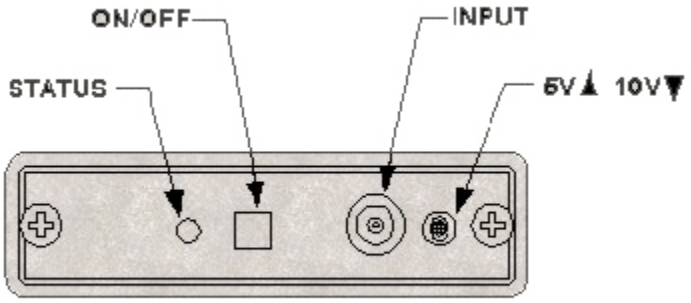
The ON/OFF button toggles the MCA8000A power between ON and OFF. An audible "ring" is sounded by the MCA when it is turned ON. A steady red light for the STATUS LIGHT indicates that the MCA is ON and no data acquisition is in progress. The STATUS LIGHT flashes steadily when data acquisition is in progress. The analog input jack uses a LEMO cable to connect it to the NaI(Tl) scintillation probe. Connection to the host computer is via a DB-9 male RS-232 serial interface (I/O) using a null modem cable. When the MCA serial port is connected to a powered host computer via this interface, the serial port is active.

The MCA8000A is powered either by two 1.5-volt AA batteries or by an external power supply via a 12-volt AC adapter connected to the power jack (center positive, 3.5 mm x 1.5 mm female barrel connector). When operating on external power, there is no drain on the AA batteries nor recharging of the batteries. The external power supply can be connected and disconnected while the MCA8000A is running on batteries. This soft power switching allows for uninterrupted operation when switching between battery and external power and vice versa.

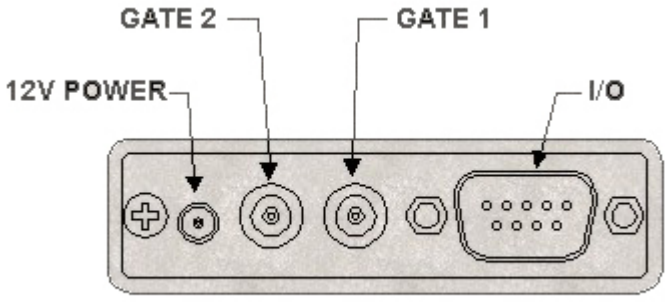
To change the batteries, first turn off the MCA8000A. Remove the battery cover, change the batteries, and replace the cover. The correct battery polarity is indicated on the bottom of the battery compartment. The MCA has a built-in



Bottom View of MCA8000A



Input Side of MCA8000A



Control Side of MCA8000A

Figure 8. Schematics of the MCA8000A unit (dimensions: 6.5-inch long x 2.8-inch wide x 0.8-inch tall). GATE 1 and GATE 2 are not used in HEU measurements. The 5V▲/10V▼ switch is set in the 5V▲ position.

Input Side of MCA8000A

Control Side of MCA8000A

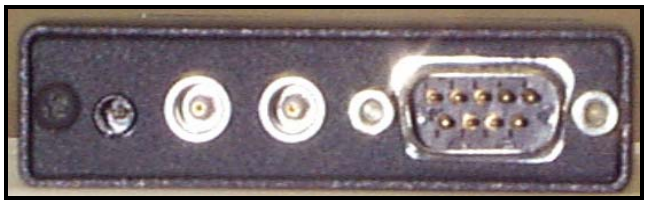


Figure 9. Photographs of the input and control sides of the MCA8000A.

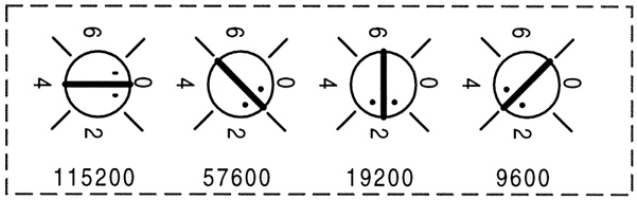


Figure 10. MCA8000A baud rate settings.

protection for reverse installed batteries. Either AA batteries or NiCad batteries may be used with the MCA8000A. To activate the built-in battery capacity meter, the appropriate battery type is selected via the MCA8000A software control. For applications with the HEU enrichment measurements, the battery type is set to AA batteries. When the MCA will not be used for more than a month, it is recommended that the batteries be removed to increase battery life.

4.3. NaI(Tl) Scintillation Probe

The 30 x 30 mm Scionix-Holland™ NaI(Tl) scintillation probe (Figure 11) is mounted on the shielding/collimator assembly by inserting the probe with the detector crystal (flat face) end first into the stainless steel collar. The control end of

the probe (Figure 12) will be positioned at the back. Using a hex wrench, loosen the compression cap screw for the probe to slide freely through the collar until it touches the collimator and stops in place (Figure 13). A reference line is marked on the probe as a guide as to how far the probe is inserted into the shielding assembly. Tighten lightly the compression screw just enough to hold the probe in place.

Figure 11. 30 x 30 mm Scionix-Holland™ NaI(Tl) scintillation probe. The probe is inserted into the mounting collar of the shielding/collimator assembly with the detector crystal end first. Connections and control are made through the control end of the probe.

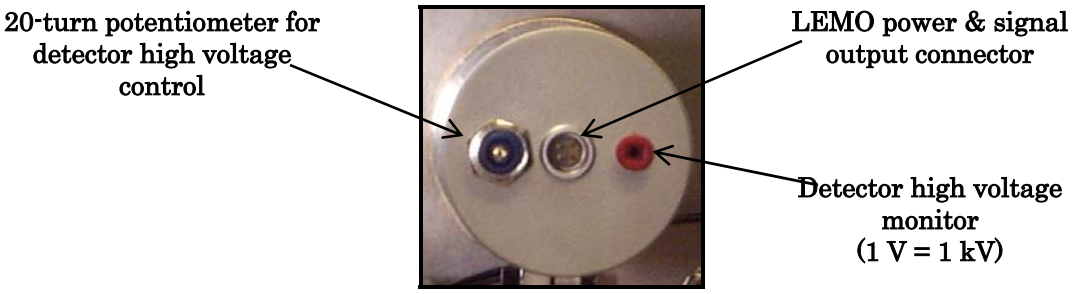


Figure 12. Control end of the 30 x 30 mm Scionix-Holland™ NaI(Tl) scintillation probe.

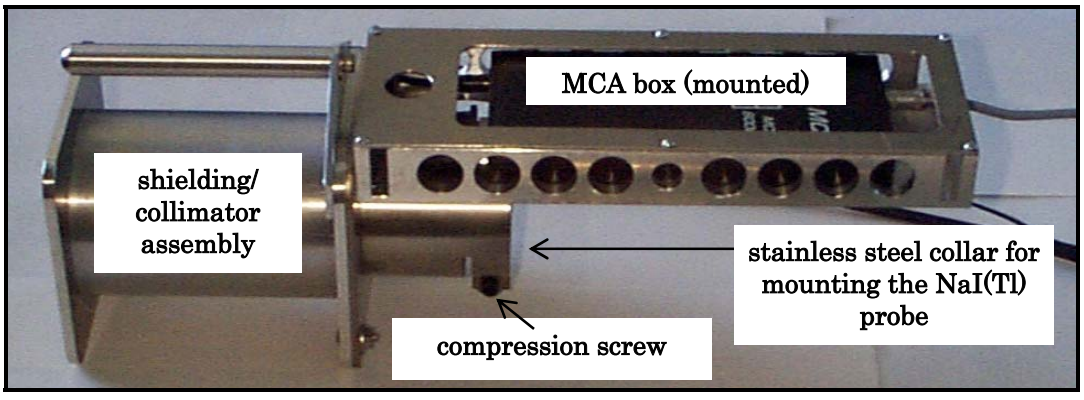


Figure 13. Mounting configuration for the NaI(Tl) scintillation probe.

4.4. PC Laptop Battery Pack

The Lithium-ion battery pack on the laptop can run continuously for 2 hours when fully charged. The battery will recharge when the computer is attached to an external power source. To maximize performance, ensure that the battery is cycled between full charge and full discharge. Do not change the battery pack until all its power is used. Recharging a battery pack that is not completely discharged can shorten battery life. Once charging of the battery pack commenced, do not use it until it is fully charged. If the computer will not be used for a long period, remove the battery pack and store it in a cool place.

To replace the battery pack, power off the computer and disconnect the AC adapter and other cables attached to it. Close the LCD/lid and turn the computer over. Slide and hold the battery pack latch to the unlocked position, then remove the battery pack. To install the new battery pack, insert it into the battery bay. The battery-pack latch automatically snaps into place.

A second battery pack can also be installed in the swappable bay device to increase battery-operation period. Before swapping the device in the UltraBay FX, activate the "Swap Bay" icon on the taskbar and click "Change Swap Bay". Click "OK" to accept the selection. Shutdown the computer and turn it off. Slide and hold the UltraBay FX device lock to the unlock position; then pull to remove the UltraBay FX device. Insert a battery pack into the UltraBay FX. The UltraBay FX device lock automatically snaps into place. Slide the battery pack extension cover to complete the installation.

4.5. Cable Connections

For ease of assembly, all cables to the MCA8000A should be connected prior to placing the unit in the MCA aluminum box. Likewise, cable connections or adjustments to the NaI(Tl) scintillation probe should be done while the probe is mounted on the shielding/collimator assembly.

4.5.1. External Power Source

Both the MCA88000A and the PC Laptop have options to run on batteries or external electrical power. For external power supply to the

MCA8000A, plug the connector from the 12V AC adapter cable to the power line jack on the control side of the MCA8000A. Plug the AC adapter to a 110V/60Hz electrical power receptacle.

For external power operations of the laptop, plug the connector from the AC adapter cable to the power jack located at the rear side of the laptop. Plug the AC adapter to a 100-240VAC, 50/60HZ electrical power receptacle.

4.5.2. MCA8000A-to-Scintillation Probe connection

Connect the LEMO cable to the signal input jack on the input side of the MCA8000A (Figure 8). Connect the other end of the LEMO cable to the power supply/signal jack on the control end of the Scionix-Holland™ NaI(Tl) scintillation probe (Figure 12).

4.5.3. MCA8000A-to-PC Laptop connection

Connect the DB-9/female RS-232 null modem cable to the input/output (I/O) interface connector on the control side the MCA8000A (Figure 8). Connect the other end of the null modem cable to the serial port on the PC Laptop. Tighten by hand the retaining screws supplied on each termination of the null modem cable.

4.6. Computer Power-On

Before powering-on the computer, ascertain that all external power source connections to the computer and the MCA8000A unit (if applicable) and cable connections between the scintillation probe, the MCA8000A and the PC laptop have been properly made. Raise the laptop computer LCD/lid by sliding outward the latches on the front side of the computer. Turn on the computer by sliding forward the power switch (and releasing it after about a second of holding it) located on the left side of the laptop. The computer will boot up automatically in Microsoft Windows® 98 operating system. The Windows Password dialog box will appear in the desktop prompting the user for a "**Username**" and "**Password**". Ignore this by clicking on the **CANCEL** button.

5. Operation of the UMeter Enrichment Software

The Microsoft® Visual Basic 6.0-based UMeter enrichment code has been created to closely mimic the operations and menu selections of the older OS2-based HEU-TIP enrichment software. It is assumed that the user is familiar with basic Microsoft Windows® operations and commands. Movement of the mouse arrow (also called cursor) on the LCD/Desktop is controlled by lightly pushing on the TrackPoint Stick (Appendix II, Figure AII-1, Part No. 21) and moving it in the direction desired (while continuously pushing on the stick). In this manual, a selection in a pop-up menu dialog box may be made by any of the following:

(a) Clicking on the selection with the computer mouse or trackpoint arrow,
(b) Toggling to the selection line using the **UP** and **DOWN** scroll arrow keys on the keyboard, or
(c) Pressing the number keypad (e.g. **1**, **2**, etc.) identifying the line selection (where available).

Thus, when the manual indicates "**select**", the action may be accomplished by any of the three options above. Similarly, accepting a selection may be done by either of two ways:

(a) Clicking on the 

button with the mouse or trackpoint arrow, or
(b) Pressing the **ENTER** key on the keyboard.

5.1. UMeter Program Start Up

To start the UMeter program, double click with the left TrackPoint button on the UMeter icon (Figure 13) located on the upper right corner of the PC desktop. Clicking with the right trackpoint button on the UMeter icon and selecting "**OPEN**" in the pop up menu will also accomplish this action.

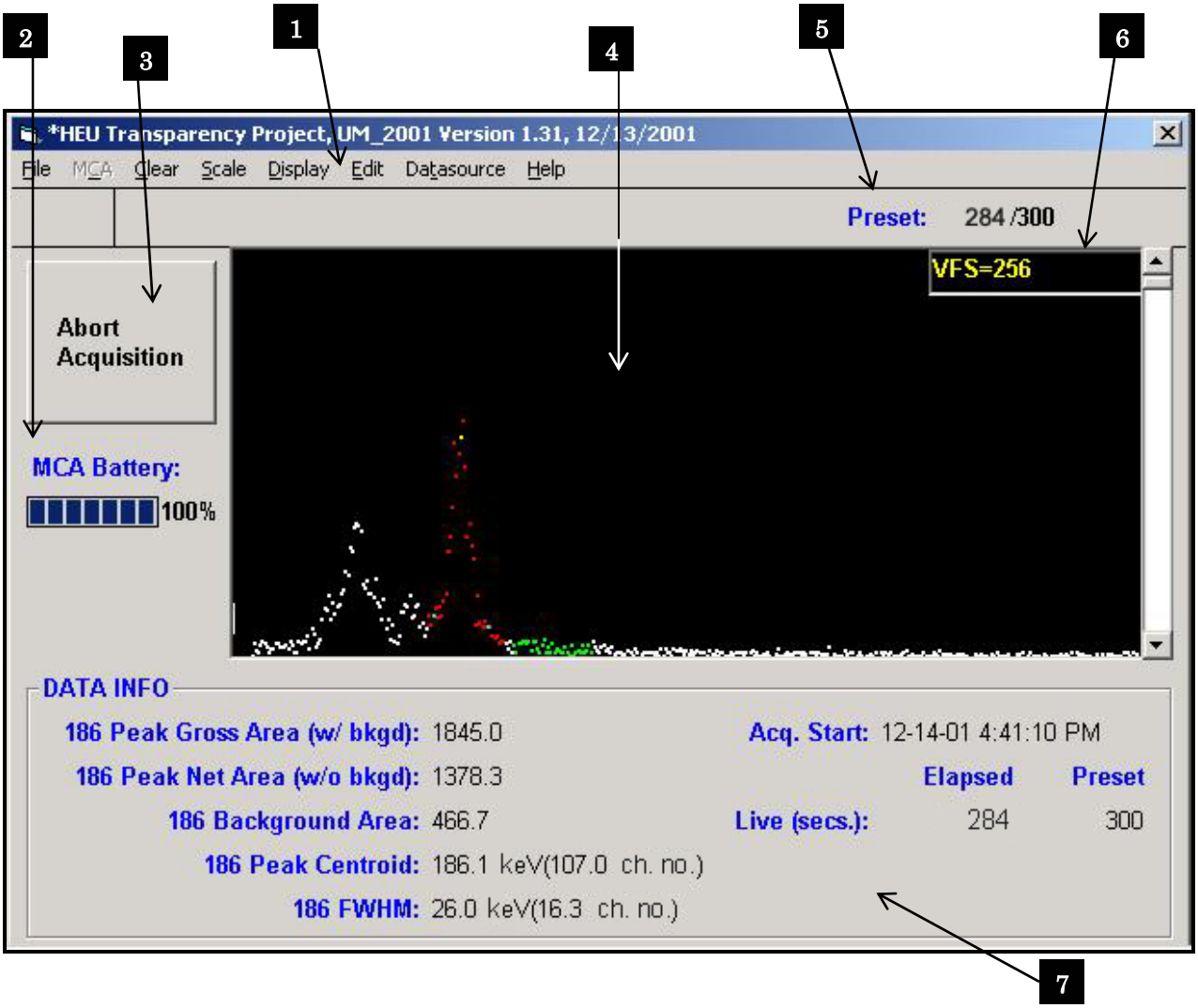
Figure 14. UMeter icon.

The program will respond with the following window:

Figure 15. "**UMeter MCA8000A Communication Connection**" window.

If the MCA8000A is initially turned off, an audible ringing alarm is sounded and signifies that a successful communication between the laptop and the MCA has been made. If, however, the MCA8000A is initially powered up (red indicator light steadily lit) no alarm will be sounded but the spectrum display window (Figure 16) will appear to signify successful connection. In the spectrum display window, the menu bar is not active during the entire process. If the MCA8000A is operating on batteries, the "**MCA Battery**" monitor bar shows the incremental capacity load of the two AA batteries and displays the value of the remaining power load to 1%. If the battery capacity level falls below 10%, a "**WARNING**" message is displayed (see Section 5.4."Warning Messages"). When connected to an external electrical power source, the battery monitor displays 100% at all time. The "**Abort Acquisition**" button, when selected, stops the data acquisition in progress (see Section 5.3. "Aborting Data Acquisition"). During data acquisition, the gamma spectrum in the **display panel**, the "**Preset**" time, and parameters in the "**DATA INFO**" box are updated in real time. The spectrum vertical full scale (**VFS**), in "number of counts per channel", adjusts automatically with the spectrum counts.

In the display panel, the 186-keV ^{235}U gamma-ray peak is highlighted in red. A yellow dot marker indicates the calculated centroid of this peak. Blue dots to the left and right of the yellow dot identify the limits of the region of interest set for the integration of the area of the 186-keV gamma peak. The centroid is calculated when a threshold of 1000 gross counts in the peak is reached and updated thereafter every 10-seconds. The background region (highlighted in green) on the high-energy side of the 186-keV peak is the background count rate used in the calculation of ^{235}U enrichment. A yellow dot is initially positioned at channel 105 until the gross peak area reaches 1000 counts. The UMeter code provides for automatic adjustment of the 186-keV peak region of interest.



1 - **Menu Bar**
2 - **MCA Battery** monitor
3 - **Abort Acquisition** button
4 - **Display Panel**
5 - **Preset Time** box
6 - **Vertical Full Scale (VFS)** box
7 - **DATA INFO** box

Figure 16. "**UMeter Spectrum Display**" window.

5.2. UMeter Program Menus

After communication between the MCA8000A and the PC laptop is established, and the spectrum window has been displayed, the "**Analysis Type**

Selection" dialog box (Figure 17) appears. Selecting "**1. UF6"** or "**2. U3O8"** gives subsequent menus that are different from that of "**3. Other – User specified**".

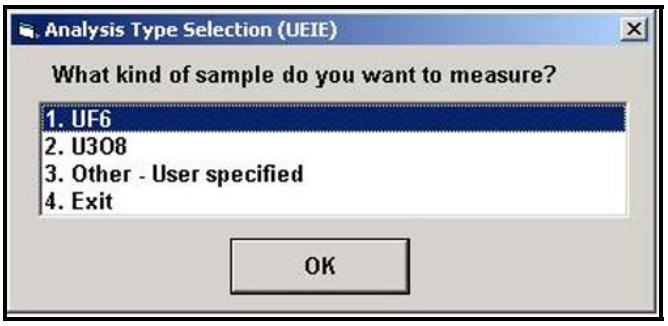


Figure 17. "**Analysis Type Selection**" dialog box.

When "**4. Exit**" is selected, the "**Shutdown**" dialog window (Figure 18) appears. After the UMeter shutdown is complete, the computer desktop is cleared of any UMeter windows. The MCA8000A can be turned off manually with the ON/OFF power switch or it automatically powers off after 5 minutes of inactivity when in battery mode.

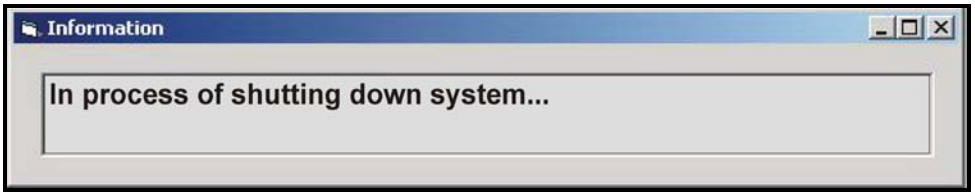


Figure 18. "**Shutdown**" dialog window.

When either "**1. UF6"** or "**2. U3O8"** is selected, the user is prompted for the analysis **acquisition time** (Figure 19). Type in the desired time in seconds and select 

or press the **ENTER** key. A 60-sec count time is usually adequate.

Figure 19. "**Acquisition Time**" dialog box.

Then the "**Data Acquisition Set Up**" window appears (Figure 20). Within a few seconds, the "**Data Acquisition In Progress**" window (Figure 21) will appear and the spectrum display window (Figure 16) becomes active as the counts in the uranium spectrum start to accumulate.

Figure 20. "**Data Acquisition Set Up**" window.

Figure 21. "**Data Acquisition In Progress**" window.

To confirm that the unit is functioning properly, examine the spectrum to evaluate that a reasonable spectrum is being accumulated. Ensure that the 186-kev ^{235}U gamma peak is at channel number 105 ± 5 or energy 186 ± 3 keV.

When the user-specified preset live time has been reached, the "**Sample Container Number**" (Figure 22) dialog box appears. Type in the desired sample identifier and select OK or press the **ENTER** key.

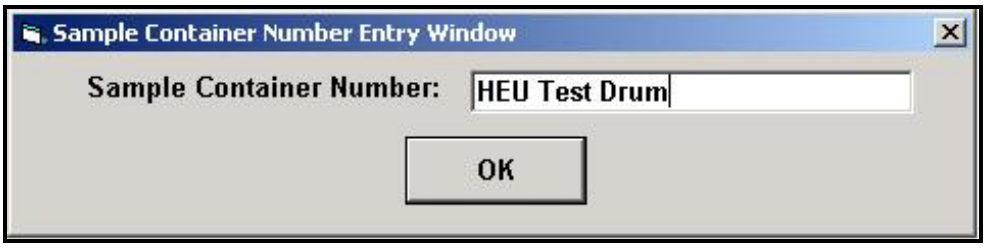


Figure 22. "**Sample Container Number**" dialog box.

The "**HEU Enrichment Report**" dialog box (Figure 23) is displayed giving information on the Run# (automatically incremented from one run to the next), the Container ID entered in Figure 22, the container material and thickness specified by the user or default values for UF_6 and U_3O_8, and the measured enrichment (%). Record this information in the NDA Monitoring Form. This information is not saved in the computer. When OK is selected or **ENTER** is pressed, the process is cycled back to the "**Analysis Type Selection**" dialog window (Figure 17).

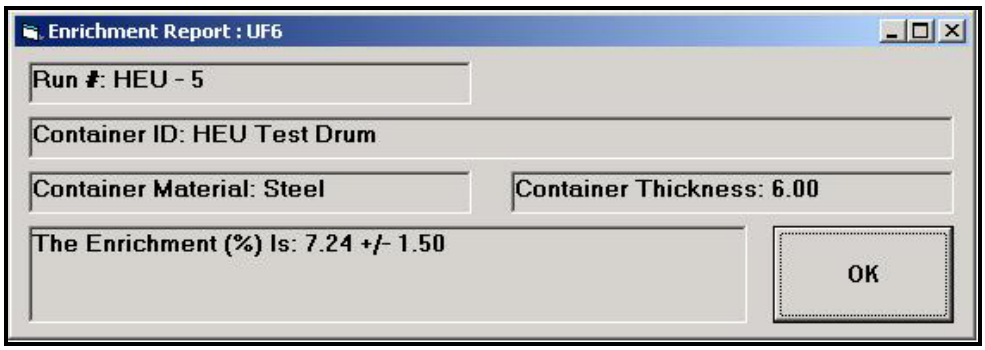


Figure 23. "**HEU Enrichment Report**" dialog box.

When "**3. Other – User specified**" is selected in the "**Analysis Type Selection**" dialog box (Figure 17), the user is presented with additional pop up menus and dialog boxes. First, the program goes through the same order of windows and dialog boxes as in Figure 19 through Figure 22. After the user-specified "**Sample Container Number**" is entered (Figure 22), the "**Select Material Type**" dialog box appears (Figure 24).

Figure 24. "**Select Material Type**" dialog box.

After selecting the appropriate uranium material type, the user is prompted for the wall material in the "**Select Wall Material**" dialog box shown in Figure 25 and subsequently with the wall thickness in the "**Wall Thickness**" dialog box (Figure 26). Type in the wall thickness in millimeters (mm) and select OK or press the **ENTER** key. The "**HEU Enrichment Report**" dialog box (Figure 23) is displayed and the program retraces the cycle until "**4. Exit**" is selected in the "**Analysis Type Selection**" dialog box (Figure 17) and the system goes through the shutdown process.

Figure 25. "**Wall Material Type**" dialog box.

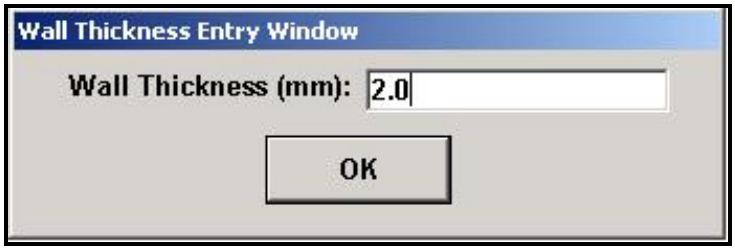


Figure 26. "**Wall Thickness**" dialog box.

Recommended container wall thicknesses for the different Russian processing plants, uranium chemical forms and container types are provided in Table I. If the Russian staff use different values, note the value on the NDA monitoring form and request an explanation for the new wall thickness number used.

Table 1. Recommended wall thickness (mm) for steel containers.

Russian Facility	Material/Container Type	Wall Thickness (mm)
SChE	Weapons component transport container	4.5
	Weapons component shop container	7.0
	Metal chip container	6.5
	5-liter oxide container	4.0
	3-liter oxide shipping container	3.5
	UF_6 cylinder	6.0
UEIP	UF_6 cylinder	5.7
ECP	UF_6 cylinder	4.0
	3-liter shipping container	3.5
MPA	Weapons component shipping container	4.5
	Metal chip container	6.5
	Oxide to purification	5.0
	Oxide from purification	6.0
	Oxide shipping container	3.5

SChE - Siberian Chemical Enterprise, Seversk
UEIP - Ural Electrochemical Integrated Enterprise, Novouralsk
ECP - Electro Chemical Plant, Zelenogorsk
MPA - Mayak Production Association, Ozersk

5.3. Aborting Data Acquisition

During the spectrum accumulation phase, the run can be aborted by clicking with the mouse cursor/arrow on the "**Abort Acquisition**" function [3] in the "**UMeter**

Spectrum Display" window (Figure 16). The data acquisition is stopped and the user will be returned to the "**Analysis Type Selection"** dialog box (Figure 17) to start a new cycle of measurement.

5.4. Warning Messages

Four warning messages may be encountered during the course of running the UMeter enrichment program. These are related to failed connection between the MCA8000A and the Computer, low battery capacity level if the MCA8000A is being operated in battery mode, low count rate in the 186-keV ^{235}U gamma peak, and significant spectrum gain shifting.

5.4.1. Failed Connection Between MCA8000A and the Computer

If communication between the MCA8000A and the laptop computer cannot be established within 15 seconds of starting the UMeter program, the warning message in Figure 27 is displayed. Select OK or press the **ENTER** key. The current run will be aborted and the "**Shutdown**" dialog box (Figure 18) will appear. The program will automatically exit. Check that the proper RS-232 cable is used (null modem) and that cable connections to the serial ports on the MCA8000A and the PC laptop are tight and properly made. Check that the MCA8000A AA batteries are charged; replace if necessary.

Figure 27. "**Failed MCA8000A-to-PC Laptop Communication**" dialog box.

5.4.2. Low Battery Capacity Level

If the MCA8000A is operating on batteries, when the load of the two AA batteries used in the MCA8000A falls below 10% of capacity, the warning message in Figure 28 is displayed. Select OK or press the **ENTER** key. Abort the run (Section 5.3) and select "**4. Exit**" in the "**Analysis Type Selection**" to shutdown the UMeter program. There is no need to shutdown the PC laptop. Manually power off the MCA8000A by pressing the ON/OFF switch (Figure 8, input side). Remove the MCA8000A unit from the MCA box. There is no need to disconnect the cables attached to the MCA. Replace the used batteries with two new batteries (Figure 8, bottom view). Re-install the MCA8000A unit into the MCA box. Re-start the UMeter program as in Section 5.1 to begin the enrichment measurements. *Note: This warning message will not activate when the MCA8000A is operated on external electrical power source.*

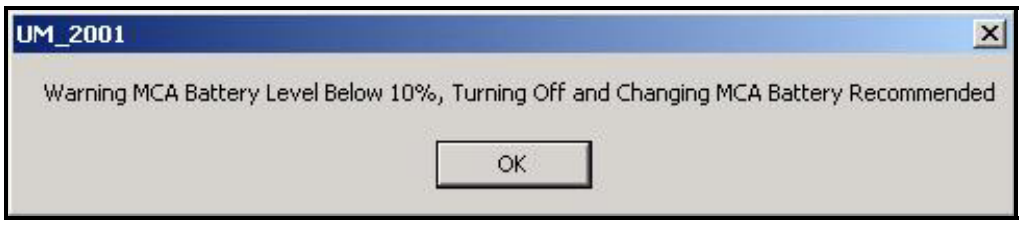


Figure 28. "**Low Battery Level Warning**" dialog box.

5.4.3. Low Count Rate in the 186-keV ^{235}U Gamma Peak

If no counts or low count rate (< 1 count per second in 10 seconds) is observed in the 186-keV ^{235}U gamma peak, the warning message in Figure 29 is displayed. Select OK or press the **ENTER** key. The run will be aborted and the UMeter program will automatically exit and shutdown. Check that there is power on the MCA8000A unit. Ensure that cable connections are properly made and that communication between the MCA and the PC laptop has been established. Check that the detector is properly positioned as close as

possible to the sample container. Re-start the UMeter program as in Section 5.1 to begin the enrichment measurements.

Figure 29. "**Low ^{235}U 186-keV Gamma Peak Count Rate Warning**" dialog box.

5.4.4. Peak Shifting of the 186-keV ^{235}U Gamma Peak

The UMeter detector is calibrated such that the 186-keV peak centroid is positioned at channel number 105 in a 512-channel ADC gain. If during an enrichment determination run, the measured peak centroid shifts by more than ± 5 channels from channel 105 (that is below channel number 100 or above channel number 110), the warning message in Figure 30 is displayed. Select 

or press the **ENTER** key. The data acquisition is stopped and the user will be returned to the "**Analysis Type Selection"** dialog box (Figure 17).

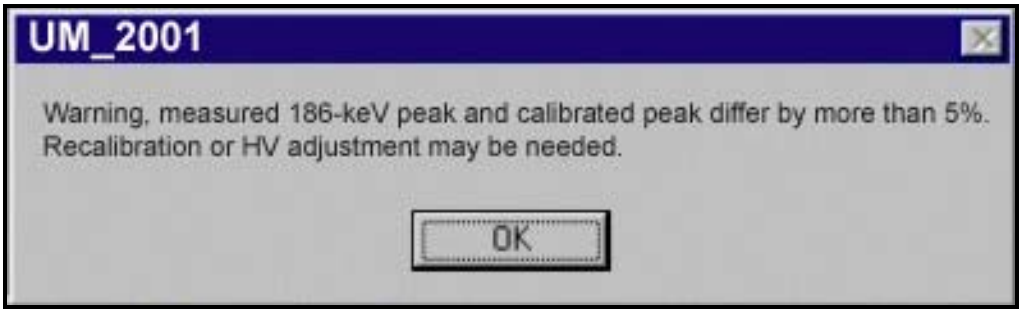


Figure 30. "**Peak Shifting of ^{235}U 186-keV Gamma Peak Warning**" dialog box.

Before proceeding further with the measurements, adjust the detector high voltage (HV) bias by turning the 20-turn potentiometer on the control end of the NaI(Tl) scintillation probe (Figure 12). [***Note:***

Prior to adjusting the HV bias, allow at least 5 minutes of continued operations of the MCA8000A unit as a warm up period for stable performance.] The aid of a voltmeter will make the adjustments easier. Insert the live probe (usually colored "red") of the voltmeter into the scintillation detector high voltage monitor. Touch the common (ground) probe of the voltmeter to the body of the scintillation probe. Record the current HV setting (*Note: a 1-volt reading corresponds to an actual 1-kilovolt bias).* If the measured 186-keV peak centroid is below channel 105, increase the HV bias by turning the potentiometer with a screwdriver clockwise to move the peak up towards channel 105. If the measured 186-keV peak centroid is above channel 105, decrease the HV bias by turning the potentiometer counterclockwise to move the peak down towards channel 105. Acquire a spectrum (Section 5.2) to observe where the new centroid for the peak appears. Repeat this process accordingly until the peak centroid is at channel 105 ± 1.

If the high voltage adjustment does not correct the peak-shifting problem, the detector needs recalibration. Exit the UMeter program. Disconnect the detector unit from the PC laptop and replace it with a working unit. Submit the "out of specification" detector for recalibration and/or further testing.

6. System Shutdown and Disassembly

System shutdown involves first exiting the UMeter program and then turning off the PC laptop. Disassembly of the equipment should be done only after both the detector unit and the computer have been powered off.

6.1. Exiting the UMeter Software

Select "**4. Exit**" in the "**Analysis Type Selection**" dialog box (Figure 17). The "**Shutdown"** dialog window (Figure 18) appears. In about 5 seconds, the UMeter shutdown is complete and the computer desktop will be cleared of any UMeter

windows. Turn the power off on the MCA8000A manually with the ON/OFF power switch. The MCA8000A automatically powers off after 5 minutes of inactivity when in battery mode.

6.2. Shutting Down the PC Laptop

Point the TrackPoint cursor/arrow to "**Start**" in the bottom left corner of the Windows® taskbar and select "**Shut Down**" (Figure 31).

Figure 31. "**Start**" and "**Shut Down**" options in the Windows® taskbar.

The "Shut Down Windows" dialog box (Figure 32) appears. Select "**Shut down**". Select OK or press the **ENTER** key. The computer will go through the standard Microsoft Windows® shutdown procedure. When the Windows® shutdown process is completed, the screen will turn blank and power to the computer will automatically be turned off. Close the LCD/lid screen until it latches onto the computer body.

Figure 32. "**Shut Down Windows**" dialog box.

6.3. System Disassembly

Disconnect the RS-232 cable from the PC laptop serial port. If the PC laptop is operated on external power source, remove the power cable from the computer. Disconnect the LEMO cable from the NaI(Tl) scintillation probe. The detector unit can be stored in the aluminum carrying case without further disassembly of its components and with all of the cables attached to MCA8000A unit. When packaging the Portable NDA II equipment in the case, make sure that the cables are not in a position where they could be pinched.

When the storage packaging is finished, be sure that the NDA II storage case is sealed at any time that the equipment is not under observation by U.S. Monitors.

Appendix II.
ACRONYMS

ADC ..... Analog-to-Digital Converter

DOE ..... Department of Energy

FWHM ..... Full Width at Half Maximum

HEU ..... Highly Enriched Uranium

HEU-TIP ..... Highly Enriched Uranium – Transparency Implementation Program

HV ..... High Voltage

IBM ..... International Business Machine

I.D. ..... Inner Diameter

I/O ..... Input/Output

LCD ..... Liquid Crystal Display

LLNL ..... Lawrence Livermore National Laboratory

MCA ..... Multichannel Analyzer

NDA ..... Nondestructive Assay

O.D ..... Outer Diameter

PC ..... Personal Computer

PMT ..... Photomultiplier Tube

TTL ..... Transistor-to-Transistor Logic